The present invention relates to a process for reducing coal consumption in coal fired power plant with steam-piping drying, namely a steam-piping drying system is provided between a coal grinding mill and a coal powder bunker as well as a weighing belt of the prior coal fired boiler generating set, and superheated steam which have done partial work is extracted from an steam turbine and used as a drying medium, moisture contained in the coal powder is evaporated with sensible heat and latent heat of the superheated steam, water resulted from the condensation of the superheated steam is fed into a deaerator of the steam turbine via a condensate pump for recirculation. The present invention has advantages of reducing coal consumption and saving coal, recovering residual heat, reducing emission of carbon dioxide and adopting to the national industrial policy on energy saving and emission reduction.
PROCESS FOR REDUCING COAL CONSUMPTION IN COAL FIRED POWER PLANT WITH STEAM PIPING DRYING

FIELD OF THE INVENTION

[0001] The present invention relates to a technical field of energy-saving and consumption reduction in coal-fired generator sets in power plants, and more particularly to a process for reducing coal consumption in coal-fired power plants with steam piping drying.

BACKGROUND OF THE INVENTION

[0002] Coal-fired steam generating set is a steam power cycle system based on Rankine cycle and comprises a condenser-type generating set and a coal-fired boiler generating set, the operational procedure of the coal-fired steam generating set is as follows: raw coal is dried and crushed into coal powder via a coal grinding mill, the coal powder is fed into a boiler and combusted so as to release heat, water absorbs heat at a certain pressure in a steam drum of the boiler and evaporated into saturated steam. The saturated steam absorbs heat in a superheater and is changed into superheated steam, the superheated steam expands and does work to outside via a steam turbine, and a certain heat loss occurs. After the superheated steam has done work due to expansion in the steam turbine, exhaust steam at an outlet at a tail end of the steam turbine is fed into a condenser so as to perform cold-source heat dissipation and condense into water. The water is sequentially fed into a shaft gland heater and a multi-stage low pressure heater (i.e., a first low pressure heater, a second low pressure heater, a third low pressure heater and a fourth low pressure heater) and heated stage by stage; the heated water is fed into a deaerator for oxygen removal, enhanced in pressure via a water feed pump, fed into a multi-stage high pressure heater (i.e. a fifth high pressure heater, a sixth high pressure heater, a seventh high pressure heater, and an eighth high pressure heater) and reheated; the reheated water is fed into a coal economizer so as to be further heated in the boiler system, and then fed into the steam drum for steam-liquid separation; the saturated steam is discharged from the steam drum and fed into the superheater of the boiler, heated by the superheater of the boiler into superheated steam with a certain temperature, the superheated steam is fed into the steam turbine for generating electricity. The above procedure has the following disadvantages.

A. The coal powder which is fed into a coal pulverizing system (such as a coal grinding mill, a coal grinding air blower, and so on) and a boiler contains moisture, the moisture will be evaporated in the coal pulverizing system and a furnace of the boiler, the required heat for evaporation of the moisture is supplied by a combustion heat result from the combustion of the coal powder self in the boiler, therefore it is necessary to consume a large quantity of the coal powder so as to evaporate the moisture contained in the coal powder.

B. During generating electricity by the superheated steam in the steam turbine, conversion rate from heat energy of the superheated steam to the electric energy is less than 50%, the reason for low generating efficiency lies in: with a process of heating a condensing water by extraction steam from the steam turbine, about one third of evaporation latent heat of the superheated steam is used, about two third of evaporation latent heat of the superheated steam can not be used and only is carried away by a condensing medium via the condenser so as to be dissipated via a water cooling tower or an air cooling island, so the latter part is a maximum heat consumption which can not be used, namely cold-source loss of the condensing-type generating set.

SUMMARY OF THE INVENTION

[0003] In view of the above description, an object of the present invention is to provide a process for reducing coal consumption in coal-fired power plant with steam-piping drying, namely a steam-piping drying system is provided between a coal grinding mill and a coal powder bunker as well as a weighing belt of the existing coal-fired boiler generating set, and superheated steam which have done partial work is extracted from a steam turbine and used as a drying medium; moisture contained in the coal powder is evaporated with sensible heat and latent heat of the superheated steam, water resulted from the condensation of the superheated steam is fed into a deaerator of the steam turbine via a condensate pump for recirculation.

[0004] In order to achieve the object of the present invention, the present invention provides a process for reducing coal consumption in coal-fired power plant with steam-piping drying, comprising steps of: providing a steam-piping drying system between a coal grinding mill and a coal powder bunker as well as a weighing belt; weighing raw coal from the coal powder bunker by the weighing belt and feeding the weighed raw coal into the steam-piping drier; drying the coal powder with superheated steam extracted from a steam turbine; feeding the dried coal powder into the coal grinding mill for pulverizing, at the same time enhancing atmospheric air in pressure via a coal powder air blower and heating the atmospheric air via the boiler preheater and then feeding the heated atmospheric air into the coal grinding mill; blowing the pulverized coal into a furnace of the boiler for combusting so as to release heat; evaporating water in a steam drum of the boiler into a saturated steam by heat absorption at a certain pressure, having the saturated steam absorb heat in a superheater of the boiler and changed into superheated steam, feeding the superheated steam into the steam turbine and having the superheated steam to be expanded and do work for exterior so as to generate electricity; feeding low pressure steam (an exhaust steam) after having done work and generated electricity into a condenser and having the exhaust steam to be condensed into water so as to release latent heat, feeding the condensed water into a shaft gland heater and a multi-stage low pressure heater (i.e. a first lower low pressure heater, a second lower low pressure heater, a third lower low pressure heater and a fourth lower low pressure heater) in turn via a condensate pump so as to heat the condensed water in stage by stage by heating medium respectively from extraction steam of a seventh section, a sixth section, the fifth section, and a fourth section of the steam turbine, and then feeding the heated condensed water into a deaerator for removal of oxygen so as to be a boiler feed water; enhancing the boiler feed water after removal of oxygen in pressure via a feed water pump of the boiler, feeding the pressurized boiler feed water into a multi-stage high pressure heater (i.e. a fifth high pressure heater, a sixth high pressure heater, a seventh high pressure heater) for reheating by heating medium respectively from extraction steam of a third section, a second section, and a first section of the steam turbine, feeding the reheated boiler feed water into a coal economizer and further heating the some in the boiler system, and feeding the further heated boiler feed water into the steam drum for
steam-liquid separation so as to be saturated steam, discharging the saturated steam from the steam drum and feeding the saturated steam into a superheater of the boiler to heat the saturated steam into superheated steam, and feeding the superheated steam into the steam turbine for generating electricity so as to perform Rankine cycle.

The superheated steam from extraction steam of the forth section or the fifth section of the steam turbine is fed into the steam-piping drying system so as to dry the coal powder. Steam and noncondensable vapor evaporated from the coal powder are fed into a dust collector for removal of dust, the tail gas after removal of dust is discharged completely via a tail gas fan. The dried coal powder is fed into the coal grinding mill. The water condensed from the superheated steam is fed into a condensate pot, enhanced in pressure via the condensate pump, and then fed into the deaerator for removal of oxygen.

The steam-piping drying system comprises the steam-piping dryer, the dust collector, the tail gas fan, the condensate pot, and the condensate pump.

Drying medium used in the steam-piping drying system is extraction steam from the steam turbine, the extraction steam is from the first section, the second section, the third section, the fourth section, the fifth section, the sixth section or the seventh section of the steam turbine, and the extraction steam has a pressure of 0.6-0.8 MPa.

The steam-piping dryer in the steam-piping drying system may be a steam-piping rotary dryer, a pipe bundle dryer or a pipe dryer.

The dust collector in the steam-piping drying system may be a dry dust collector or a wet dust collector. The dry dust collector may be a cyclone separator, a bag dust collector or an electrostatic precipitator. The wet dust collector may be a Venturi wet dust collector, a swashing wet dust collector, or a wet washing tower.

The steam-piping drying system may be used for a coal powder boiler system which require a coal pulverizing system or a circulating fluidized bed boiler system without pulverizing.

In comparison with the prior art, energy-saving effect is set forth as follows.

Whether the moisture in coal fired required by the coal fired boiler generating set is evaporated in a furnace of the boiler in the prior art or in the steam-piping dryer of the present invention, it can be regarded as a dehydrating and drying process of the coal fired. Although the required heat for evaporation of the moisture is supplied by a combustion heat result from the combustion of the coal in the boiler, there are the following differences in supplying the required heat.

(1) In the prior art, the required heat for evaporation of the moisture contained in the coal powder in the coal pulverizing system and the furnace of the boiler is directly supplied by a combustion heat result from the combustion of the coal powder. As long as the coal powder contains moisture, some of the combustion heat will be used to evaporate the moisture, more moisture is contained in the coal powder, more coal powder will be consumed, and vice versa.

(2) In the present invention, the required heat for evaporation of the moisture contained in the coal powder in the steam-piping dry system is supplied by the extraction steam which has done partial work in the steam turbine in manner of indirectly heat exchange. A process of extracting the superheated steam from the steam turbine for drying the coal powder in the steam-piping dryer is similar to a process of condensing the superheated steam into water in the condenser. One part of the heat consumed in drying the coal powder in the steam-piping dryer is sensible heat; other part is steam latent heat. During the superheated steam is condensed into water in the steam-piping dryer, most of heat released is steam latent heat and it is also a cold-source dissipated by the condenser. It has been found that the heat for drying in the steam-piping drier which is from the extraction steam of the steam turbine, is the same as a cold-source heat dissipation loss of the exhaust steam discharged from the steam turbine during the condensation process in the condenser. How much heat of the extraction steam from the steam turbine is consumed by the drying process, the cold-source will reduce the same amount of the heat dissipation loss. Therefore, the steam-piping drying system provided ahead of the coal pulverizing system or the boiler will reduce the amount of coal consumption in the generating set and a rate of self-used power. Hereinafter, it will be described by way of example. Lignite containing total moisture of 33% is dried respectively to one containing total moisture of 8% and one containing total moisture of 15%, whose parameters of coal quality are respectively as follows.

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>Symbol</th>
<th>Unit</th>
<th>Wet coal</th>
<th>Dried coal 1</th>
<th>Dried coal 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total moisture</td>
<td>Mt</td>
<td>%</td>
<td>33.40</td>
<td>8.00</td>
<td>15.00</td>
</tr>
<tr>
<td>2</td>
<td>moisture (air drying basis)</td>
<td>Mad</td>
<td>%</td>
<td>13.04</td>
<td>8.00</td>
<td>13.04</td>
</tr>
<tr>
<td></td>
<td>Free-moisture</td>
<td>Mf</td>
<td>%</td>
<td>23.41</td>
<td>0.00</td>
<td>2.25</td>
</tr>
<tr>
<td>3</td>
<td>Correction coefficient</td>
<td></td>
<td>—</td>
<td>1.00</td>
<td>1.38</td>
<td>1.28</td>
</tr>
<tr>
<td>4</td>
<td>Ash content (as received basis)</td>
<td>Aar</td>
<td>%</td>
<td>8.66</td>
<td>11.96</td>
<td>11.05</td>
</tr>
<tr>
<td>5</td>
<td>Volatile Matter (dry ash-free basis)</td>
<td>Vdaf</td>
<td>%</td>
<td>44.65</td>
<td>44.65</td>
<td>44.65</td>
</tr>
<tr>
<td>6</td>
<td>Carbon (as received basis)</td>
<td>Car</td>
<td>%</td>
<td>42.97</td>
<td>59.36</td>
<td>54.84</td>
</tr>
<tr>
<td>7</td>
<td>Hydrogen (as received basis)</td>
<td>Har</td>
<td>%</td>
<td>2.86</td>
<td>3.95</td>
<td>3.65</td>
</tr>
<tr>
<td>8</td>
<td>Oxygen (as received basis)</td>
<td>Our</td>
<td>%</td>
<td>11.35</td>
<td>15.68</td>
<td>14.49</td>
</tr>
<tr>
<td>9</td>
<td>Nitrogen (as received basis)</td>
<td>Nin</td>
<td>%</td>
<td>0.61</td>
<td>0.84</td>
<td>0.78</td>
</tr>
<tr>
<td>10</td>
<td>Total sulphur</td>
<td>St, ar</td>
<td>%</td>
<td>0.15</td>
<td>0.21</td>
<td>0.19</td>
</tr>
<tr>
<td>11</td>
<td>High caloric value (as received basis)</td>
<td>Qgr, ar</td>
<td>MJ/kg</td>
<td>16.51</td>
<td>22.98</td>
<td>21.23</td>
</tr>
<tr>
<td>12</td>
<td>Low caloric value (as received basis)</td>
<td>Quet, ar</td>
<td>MJ/kg</td>
<td>15.15</td>
<td>21.89</td>
<td>20.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kcal/kg</td>
<td></td>
<td>3623</td>
<td>5227.19</td>
<td>4783.85</td>
</tr>
<tr>
<td>13</td>
<td>Handgrove grindability index</td>
<td>HGI</td>
<td>—</td>
<td>67</td>
<td>67</td>
<td>67</td>
</tr>
</tbody>
</table>
[0013] With respect to a general generating set having a generation power of 634.34 MW, under a condition that the coal fired is not performed on drying and the extraction steam is not extracted, amount of coal consumption for the general generating set as designed is 354 t/h (total moisture is 33.4%, wet basis).

[0014] If the coal fired will be dried to total moisture of 8%, when the extraction steam by extracting from the fifth section at 120 t/h (the parameter of extraction steam is that the superheated steam has 0.57 MPa(A) and 280°C.) is used to dry the coal fired and the total moisture of the coal fired is dried to 8%, the actual amount of coal consumption of the generating set is 248 t/h (8.0%, wet basis), which is converted into an amount of coal consumption of 342.57 t/h (total moisture is 33.4%, wet basis) before drying. In comparison with the general generating set, the amount of coal saved through drying the coal fired into total moisture of 8% by the drying and extraction steam generating set is as follows:

\[
\text{354 - 342.57 = 11.43 t/h, which is converted into a standard coal of 9.44 g/kWh.}
\]

[0015] If the coal fired will be dried to total moisture of 15%, when the extraction steam by extracting from the fifth section at 100 t/h (the parameter of extraction steam is that the superheated steam has 0.57 MPa(A) and 280°C.) is used to dry the coal fired and the total moisture of the coal fired is dried to 15%, the actual amount of coal consumption of the generating set is 271 t/h (15%, wet basis), which is converted into an amount of coal consumption of 345.86 t/h (total moisture is 33.4%, wet basis) before drying. In comparison with the general generating set, the actual amount of coal saved through drying the coal fired into total moisture of 15% by the drying and extraction steam generating set is as follows:

\[
\text{354 - 345.86 = 8.14 t/h, which is converted into a standard coal of 6.64 g/kWh.}
\]

[0016] The technical advantages of the present invention are as follows:

1. In the present embodiment, the steam-piping drying system comprises a steam-piping dryer 19, a dust collector 20, a tail gas fan 21, a condensate pot 22, and a condensate pump 23. The steam-piping dryer 19 as used here is a steam-piping rotary dryer. The dust collector 20 is a bag dust collector. The boiler 4 of the steam-piping coal drying system is a coal powder boiler system of a coal pulverizing system.

2. Hereinafter, a flowchart of a process for reducing coal consumption in a coal fired power plant with steam-piping drying will be further described with reference to FIG. 1.

[0021] After raw coal from a coal powder bunker 1 is weighed by a weighing belt 2, the raw coal is fed into the
steam-piping dryer 19. Superheated steam extracted from a fourth section or a fifth section of a steam turbine 5 is fed into the steam-piping dryer 19 to dry coal powder and the superheated steam has a pressure of 0.7 MPa. The dried coal powder is fed into a coal grinding mill 3 so as to be pulverized, and at the same time, atmosphere air is enhanced in pressure via a coal powder air blower 18, the atmosphere air is heated via the preheater of the boiler 4 and then fed into the coal grinding mill 3, the pulverized coal is blown into a furnace of the boiler 4 and combusted with assistance of a combustion fan 17. The pulverized coal releases heat due to the combustion in the furnace of the boiler 4, so that water in a steam drum of the boiler 4 is evaporated into a saturated steam via heat absorption at a certain pressure, the saturated steam absorbs heat in a superheater of the boiler 4 and is converted into superheated steam, the superheated steam is expanded via the steam turbine 5 and does work for exterior so as to generate electricity. A low pressure steam (an exhaust steam) after having done work and generating electricity is fed into a condenser 6 and condensed into condensing water so as to release latent heat, the condensing water is enhanced in pressure via a condensate pump 7 and then fed into a shaft gland heater and a multi-stage low pressure heater (i.e. a first lower low pressure heater 8, a second lower low pressure heater 9, a third lower low pressure heater 10 and a fourth lower low pressure heater 11) in turn and heated in stage by stage by heating medium respectively from extraction steams of a seventh section, a sixth section, the fifth section, and a fourth section of the steam turbine, and then the heated condensing water is fed into a deaerator 12 for removal of oxygen so as to be a boiler feed water. The boiler feed water is enhanced in pressure via a feed water pump 13 of the boiler 4, fed into a multi-stage high pressure heater (i.e. a fifth higher pressure heater 14, a sixth higher pressure heater 15, a seventh high pressure heater 16) and reheated by heating medium respectively from extraction steams of a third section, a second section, and a first section of the steam turbine, the reheated boiler feed water is fed into a coal economizer so as to be further heated in the boiler system, and the further heated boiler feed water is fed into the steam drum for steam-liquid separation, the saturated steam is discharged from the steam drum and fed into a superheater of the boiler and is heated into the superheated steam, the superheated steam is fed into the steam turbine for generating electricity so as to perform Rankine cycle.

1. A process for reducing coal consumption in a coal fired power plant with steam-piping drying, comprising the steps of:

- weighing raw coal from a coal powder bunker of a coal fired boiler generating set by a weighing belt;
- feeding the weighed raw coal into an steam-piping drying system;
- extracting superheated steam from a fourth section or a fifth section of a steam turbine and feeding the superheated steam into the steam-piping drying system to dry the coal powder;
- feeding steam and noncondensable gas evaporated from the coal powder into a dust collector for removal of dust and discharging tail gas after removal of dust completely via a tail gas fan;
- feeding the dried coal powder into a coal grinding mill;
- condensing the superheated steam for drying into water, and feeding the condensed water into a condensate pot, enhancing the condensed water in pressure via a condensate pump, and then feeding the pressurized water into a deaerator;
- mixing the pressurized water with condensed water which has been heated by a multi-stage low pressure heater so as to be a boiler feed water with performing removal of oxygen together;
- feeding the boiler feed water into a fifth high pressure heater, a sixth high pressure heater, and a seventh high pressure heater via a feed water pump in turn and reheating the boiler feed water by heating medium from extraction steam of a third section, a second section, and a first section of the steam turbine; and
- feeding the reheated boiler feed water into a coal economizer so as to be further heated in the boiler system, feeding the further heated boiler feed water into a steam drum for steam-liquid separation so as to be saturated steam, discharging the saturated steam from the steam drum, and feeding the saturated steam into a superheater of the boiler, heating the saturated steam into superheated steam in the superheater of the boiler, and feeding the superheated steam into the steam turbine for generating electricity so as to perform a Rankine cycle.

2. The process for reducing coal consumption in a coal fired power plant with steam-piping drying according to claim 1, wherein the steam-piping drying system comprises a steam-piping dryer, the dust collector, the tail gas fan, the condensate pot, and the condensate pump.

3. The process for reducing coal consumption in a coal fired power plant with steam-piping drying according to claim 1, wherein the drying medium used in the steam-piping drying system is extraction steam from the steam turbine, the extraction steam is from the first section, the second section, the third section, the fourth section, the fifth section, the sixth
section or the seventh section of the steam turbine, and the extraction steam has a pressure of 0.6-0.8 MPa.

4. The process for reducing coal consumption in a coal fired power plant with steam-piping drying according to claim 1, wherein the steam-piping dryer in the steam-piping drying system may be a heat conduction dryer such as a steam-pipe rotary dryer, a pipe bundle dryer or a pipe dryer.

5. The process for reducing coal consumption in a coal fired power plant with steam-piping drying according to claim 1, wherein the dust collector in the steam-piping drying system is a dry dust collector or a wet dust collector.

6. The process for reducing coal consumption in a coal fired power plant with steam-piping drying according to claim 5, wherein the dry dust collector is a cyclone separator, a bag dust collector, or an electrostatic precipitator, the wet dust collector is a Venturi wet dust collector, a washing wet dust collector, or a wet washing tower.

7. The process for reducing coal consumption in a coal fired power plant with steam-piping drying according to claim 1, wherein the boiler in the steam-piping drying system is a coal powder boiler system requiring a coal pulverizing system or a circulating fluidized bed boiler system without pulverizing.

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